6- 41- X63 APPENDIX E

#3

OMB Number 3145-0058

NATIONAL SCIENCE FOUNDATION
4201 Wilson Blvd.
Arlington, VA 22230

PI/PD Name and Address

James L. Gole
School of Physics
Georgia Tech Research Corporation - GIT
Atlanta, GA 30332-0430

NATIONAL SCIENCE FOUNDATION FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION

1. **Program Official/Org.** Rolf M. Sinclair, Cross Directorate Programs
2. **Program Name** NSF - REU - Physics
3. **Award Dates (MM/YY)** **From:** 4/15/96 **To:** 3/31/99
4. **Organization and Address**
   Georiga Tech Research Corporation - GIT
   Administration Building
   Atlanta, Georgia 30332
5. **Award Number** 9531372
6. **Project Title** REU: Chemical, Optical, and Condensed Matter Physics at Georgia Institute of Technology

NSF Grant Conditions (Article 17, GC-1, and Article 8, FDP-11) require submission of a Final Projects Report (Form 98A) to the NSF Program Officer no later than 90 days after the expiration date of the award. Final Project Reports for expired awards must be received before new awards can be made (NSF Grants Policy Manual Section 340).

Below, or on a separate page attached to this form, provide a summary of the completed projects and technical information. Be sure to include your name and award number on each separate page. See below for more instructions.

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

The summary (about 200 words) must be self-contained and intelligible to a scientifically or technically literate reader. Without restating the project title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent to the project being described, the following items:

- The primary objectives and scope of the project
- The techniques or approaches used only to the degree necessary for comprehension
- The findings and implications stated as concisely and informatively as possible

See attached sheet.

PART III - TECHNICAL INFORMATION (for program management use)

List references to publications resulting from this award and briefly describe primary data, samples, physical collections, inventions, software, etc., created or gathered in the course of the research and, if appropriate, how they are being made available to the research community. Provide the NSF Invention Disclosure number for any invention.

See attached sheet.

I certify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001.)

Principal Investigator/Project Director Signature	Date

IMPORTANT:
MAILING INSTRUCTIONS
Return this *entire* packet plus all attachments in the envelope attached to the back of this form. Please copy the information from Part I, Block I to the *Attention block* on the envelope.

NSF Form 98A (rev. 7/95)

JAMES L. GOLE

Award No. 9531372

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

This project, involving the chemical, optical, non-linear and condensed matter physics group in the School of Physics, was designed to provide a 10 week summer research experience for promising undergraduate students in the physical sciences. The principal objectives of the program were 1) to provide an intensive research experience to undergraduates, 2) to improve the representation of women and minorities in physics, and 3) to encourage talented undergraduates to pursue graduate study. A total of fourteen faculty members participated in this evolving program, each supervising between one and three undergraduate researchers for ten week periods in the summers of 1996, 1997, and 1998, for a total of 30 REU students. Five additional students, supported from internal funds, also participated in the program and were considered REU participants for a total of 35 students.* 11 women participated in the program from 1996 through 1998. In addition to their research experiences which will lead to a number of publications and talks at scientific meetings, at frequent intervals during the summer, the students met as a group with faculty participants to present seminars and to discuss research progress, academic plans, and the general research experience. These sessions provided one of the summer's most useful learning experiences. Most of the REU students were afforded the opportunity to interact with graduate students. They cited these contacts as valuable for learning research techniques and, perhaps more importantly, for assessing the challenges of graduate school. Several students mentioned, toward the end of their stay, that the program had imparted to them a real sense of teamwork and synergy in research. In addition they remarked that they experienced a camaraderie through arranged tours of facilities such as Lockheed Aircraft Company and extracurricular activities (camping, sports) in which they participated together.

Almost all of the REU participants in this program are now in graduate school, will be entering in the fall, or have confirmed the intent to pursue graduate study immediately. The few exceptions will attend medical school of must fill service obligations before going on to graduate study. All now have strong feelings about their relative aptitudes for experimental vs. theoretical research, and all feel better able to make an informed choice about fields of research, "big" physics vs. "little" physics, large vs. small department, etc.

*Part of the Georgia Tech matching fund contribution was used to provide an additional salary contribution (bonus) for each student who participated during the Olympic Summer (the total expenditure was the equivalent of one student participant).

JAMES L. GOLE

Award No. 9531372

PART III - TECHNICAL INFORMATION (for program management use)

PART IV - FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in response to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the information.

Please enter the numbers of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		**Post-Doctorals**		**Graduate Students**		**Under-Graduates**		**Other Participants**[1]	
	Male	**Fem.**	**Male**	**Fem.**	**Male**	**Fem.**	**Male**	**Fem.**	**Male**	**Fem.**
A. Total, U.S. Citizens							18 (5)	11 (0)		
B. Total, Permanent Residents							1			
U.S. Citizens or Permanent Residents[2]: American Indian or Alaskan Native . . .										
Asian										
Black, Not of Hispanic Origin.							1	3		
Hispanic.								1		
Pacific Islander										
White, Not of Hispanic Origin							18 (5)	7 (0)		
C. Total, Other Non-U.S. Citizens										
Specific Country 1.										
2.										
3.										
D. Total, All participants (A + B + C)							19 (5)	11 (0)		
Disabled[3]										

☐ Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

[1]Category includes, for example, college and precollege teachers, conference and workshop participants.

[2]Use the category that best describes the ethnic/racial status of all U.S. Citizens and Non-citizens with Permanent Residence. *(If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)*

[3]A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. *(Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")*

AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America, and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia and the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

BLACK, NOT OF HISPANIC ORIGIN: A person having origins in any of the black racial groups of Africa.

HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

PACIFIC ISLANDER: A person having origins in any of the original peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marianas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; and the Philippines.

WHITE, NOT OF HISPANIC ORIGIN: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.

NSF Form 98A (Rev. 7/95)

REU

CHEMICAL, OPTICAL, AND CONDENSED MATTER PHYSICS AT GEORGIA INSTITUTE OF TECHNOLOGY

Final Report for the Period

1996 - 1998

to

NATIONAL SCIENCE FOUNDATION

by

James L. Gole, PI

The chemical, optical, nonlinear, and condensed matter physics group in the School of Physics, Georgia Institute of Technology, has now completed its third session of summer undergraduate programs funded austensibly by a three year REU site grant. A total of fourteen faculty members participated in the evolving program, each supervising between one and three undergraduate researchers for ten week periods in the summers of 1996, 1997, and 1998, for a total of 30 REU students. During the summers of 1996, 1997, and 1998, the School of Physics provided matching funds for five additional undergraduates who also participated in the program and will be included in the report below.

The principal objectives of the program were as follows:
1) to provide an intensive research experience to undergraduates,
2) to improve the representation of women and minorities in physics, and
3) to encourage talented undergraduates to pursue graduate study.

All students became successfully involved in their respective research groups and reported positive experiences from the summer program. Of the 30 NSF supported participants, 11 women participated in the program from 1996 through 1998. We experienced oscillations in the year-to-year female participation in the program for many reasons which have been detailed previously. Five minority students participated in the program during the summers 1996-1998.

One of the major objectives of our program has been to include significant numbers of minorities. Toward this end, the program was advertised in many historically black colleges and universities. As an indication of this department's commitment to minority education and recruitment, we note that we have been cited in Science as one of the three outstanding minority graduate programs in the U. S. We keep track of these students. For example, in the early years of the seven years we have run this program, we were fortunate (1989) to attract Mr. L. Nathaniel Georges from the Furman University Physics Department. Nat has now completed an advanced degree in Aerospace Engineering at Notre Dame and is currently employed at Boeing and maintains contact with his former REU advisor, James Gole. Mr. Colley Baldwin (1994) is currently completing his Masters Degree in Material Science at Penn State University.

The program has evolved and undergone some significant changes during the last three year period under the guidance of Professor James Gole, who has had considerable experience with undergraduates. The program continues to undergo substantial revision (see enclosed recruitment literature), strengthening both the optical and solid state component and broadening the base of opportunity to include nonlinear dynamics and nanotechnology. In addition, primarily because of the large number of inquiries we have received from students outside of the Southeastern sector of the country, we continue to broaden our recruiting base on a national scale.

We received well over 70 completed applications in the years 1996 and 1997 and over 80 applications in 1998. Based on our experiences with the previous REU program it was decided to limit our consideration primarily to those students with a GPA of 3.6 or above unless clearly extenuating circumstances were found. (Although the GPA was not considered the sole criterion for acceptance, we found in virtually all cases that the application and letter of recommendation gave similar indications of aptitude for physics and graduate study.)

In order to provide the broadest base for evaluation, we summarize the program for the summers 1996-1998.

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*Part of the Georgia Tech matching fund contribution was used to provide an additional salary contribution (bonus) for each student who participated during the Olympic Summer (this was (total) the equivalent of one participant).

Data on Scientific Collaborators:

1. Participating faculty (Georgia Institute of Technology)
   James L. Gole (P.I.)
   Michael Chapman
   Mei-Yin Chou
   Edward Conrad
   Walter DeHeer
   William Ditto
   Phillip N. First
   Eugene Patronis
   Rajarshi Roy
   Carlos Sa De Melo
   Michael Schatz
   Li You
   Andrew Zangwill

Undergraduates

The NSF-REU grants covering the summers of 1996-1998 were used to support summer research participation for the following students:

Summer 1996*

REU Fellow	Home Institution	REU Advisor	Notes
Alexi Arango[a]	U. C. Santa Cruz	Gole	--
Susanna Castillo	Harvard	Ditto	minority female
Lynford Goddard	Stanford	First	minority
Debra Krause	U. of Dayton	Chou	female
Adam Knudson	Case Western Reserve	Zangwill	--
John McNair	Georgia Tech	Gole	--
John Stout	Georgia Tech	Gole	--

*The Olympic Year.
a. Left program after 3 weeks due to illness.

Summer 1997

REU Fellow	Home Institution	REU Advisor	Notes
Joseph Abraham	Rice University	Gole	
Seth Boyd	U. of Delaware	Ditto/Patronis	dual project and advisors
Edmonia Caldwell	Xavier, New Orleans	Conrad	minority female

David DeShazer	Georgia Tech	Roy	
Kirk Elder	Georgia Tech	Schatz	
Joel Hales	Georgia Tech	Roy	
Ginny McSwain	Georgia Tech	You	female
Davienne Monbleau	Rennsalear Polytech	Schatz	female
Martin Newmann	U. of Illinois	Gole	
Wally Opaska	James Madison Univ.	You	
Shawn Pottorf	West Georgia	Chou	
Sara Suber	Wofford College	Ditto	female

Spring and Summer 1998

REU Fellow	Home Institution	REU Advisor	Notes
Alexander Avanesov	Reed College	You	
Paul Barsic	Univ. of Oklahoma	Roy	
Edmonia Caldwell	Xavier, New Orleans	Conrad	minority female
Julie Vincentis	Bowdoin College	Gole	female
Kenneth Dickerson	Georgia Tech	DeHeer	
Pride Grimm	North Carolina	Chapman	
Joel Hales[a]	Georgia Tech	Roy	
Garth Heutel	U. of Michigan	Chou	
David Howell	Bucknell	Schatz	
Natalie Johnson	William and Mary	Roy	minority female
Richard Lepkowicz	Georgia Tech	Gole	
Christopher Meacham	Reed College	Ditto	
Devang Naik	Georgia Tech	Gole	
Candace Osborne	Cumberland College	Chapman	female
Reid Smith	Georgia Tech	Sa de Melo	female
Glen Stark	Georgia Tech	You	

a. Full participant in program supported by alternate grant funds.

Thirty-seven students participated in the program over the three year period two of which were involved in more complex projects which lasted for two quarters. 31% of the participants were women and 15% were underrepresented minorities.

During the Olympic Summer, the REU program was, of necessity, smaller. The students who participated were given a bonus to their stipends as a reward for dealing with the inconvenience necessitated by the Olympics, a packet of Subway tokens, and Marta passes. They were encouraged to take advantage of the Olympic events, especially those correlated with the adjunct symphony performances which provided inexpensive student tickets.

It is to be noted that the REU program, as well as the REU advisors, have evolved over this three year period. We have added both diversity and a fresh character through this evolution. Based on the overwhelming response of students to the program these efforts have not gone unnoticed.

Students cited three major areas of benefit from their research experiences:

Research Accomplishments. The students worked independently in individual research grops, as indicated. Specific short descriptions of the projects for each student are noted below with the major educational benefits.

Summer 1996 - The Olympic Summer

1) Alexi Arrango: worked on a combination of laser and atomic force microscope techniques to study Porous Silicon.
2) Susanna Castillo: developed programs to study the nonlinear dynamics of coupled Schmitt triggers as models of arrays of chaotic oscillators with potential application to biological systems (nonlinear dynamics modeling and computations).
3) Lynford Goddard: assembled and tested low energy electron diffraction and Auger spectroscopy apparatus (ultrahigh vacuum techniques with magnetic material - experience with STM).
4) Debra Krause: calculation of phonons in solids from force-constant matrices for fcc crystals - (learned several topics in solid state physics, programming, and use of Unix work stations).
5) Adam Knudson: worked on a model problem to address the physics of ultrathin magnetic films - films no more than a few atomic layers thick (theoretical modeling of condensed matter systems, computer modeling).
6) John McNair: participated in experiments on a project to study chemically induced Raman scattering in dense sodium gas - developed a computer model for a portion of system (optical and vacuum techniques, lasers, chemical physics).
7) John Stout: participated in studies of a visible chemical laser system and did much to streamline data evaluation (optical and vacuum techniques, lasers, chemical physics).

Summer 1997

1,2) Joseph Abraham and Martin Newmann: worked together on studies focused to the development of a visible chemical laser system (optical and vacuum techniques, lasers, chemical physics, materials science).
3) Seth Boyd: worked on projects in both acoustics and applied chaos where he (1) learned to characterize and design a dynamic loudspeaker's electroacoustical properties and (2) study the synchronization of chaos in a dynamical system (acoustics, computer modeling of nonlinear systems).
4) Edmonia Caldwell: construction and testing of a Surface Magneto-Optical Kerr system - (theory - optical and laser techniques, complex electronics, ultra-high vacuum techniques) - participant for 2nd summer on difficult project.
5) David DeShazer: developed an experimental system of three coupled lasers in a linear array to investigate its dynamical properties (optics and laser physics, computer modeling).

6) Joel Hayes: studied the instability (power dropout events) experienced by a semiconductor laser with weak feedback from an external reflector (optics and laser physics, computer modeling).
7) Mary McSwain: studied the classical Newtonian dynamics of an atom inside a magnetic trap gaining quantization knowledge about the dimensions of the physical variables involved in typical trapping experiments (computer modeling).
8) Wally Opaska: studied the influence of dissipation on the quantum state with a nonlinear oscillator model (density matrix formulations - computer modeling).
9) Kirk Elder: developed and began the construction of an experiment on the nonlinear dynamics and control of patterns in thermal fluid convection (experimental non-linear dynamics, computer modeling of instability and complexity in extended systems).
10) Davienne Monbleau: developing an experiment to characterize the motion of a particle in a fluid where the particle is subject to time-dependent forces described by narrow band noise (experimental non-linear dynamics, computing skills).
11) Shawn Pottorf: studied electronic states in a quantum dot using the variational Monte Carlo method (mastery of Fortran language - familiarity with Unix work stations).
12) Sara Suber: studied several nonlinear dynamical systems in the Applied Chaos laboratory, developed a program for smoothing time series data on human heart cells during atrial fibrillation (experimental study and modeling of nonlinear systems).

Spring and Summer 1998

1) Alexander Avanesov: studied the diffraction of atomic beams due to standing wave laser light (quantum mechanics, matter waves, numerical techniques).
2) Paul Barsic: studied the polarization properties of light emitted by diode pumped solid state lasers and the relation of pump light polarization to output light polarization - modeled simple chaotic systems to investigate chaotic multiplexing (laser physics, chaotic dynamics).
3) Edmonia Caldwell: studied time correlations in crystal surfaces, the formation of defects and their role in growth phenomena (ultrahigh vacuum techniques, computer interfacing).
4) Julie DeVincentis: studied the photoluminescent emission from porous silicon samples as a function of various surface treatments with an eye to improved photovoltaics (laser induced fluorescent experiments, materials and surface science).
5) Kenneth Dickerson: measurements of the nonlinear current-voltage characteristics of single carbon nanotubes at room temperature (atomic force microscopy, surface and cluster characterization, computer interfacing).
6) Pride Grimm: laser cooling and trapping of atoms (highly stabilized lasers, ultra high vacuum, computer control, data acquisition and imaging).
7) Garth Heutel: studied the electronic structure of many-body systems using the quantum Monte Carlo method (computer modeling in condensed matter physics).
8) David Howell: studied the damping rates of surface waves in a circular cylinder with a pinned end boundary (experimental study and computer modeling of nonlinear dynamical systems).
9) Natalie Johnson: used a fusion splicer for optical fibers to investigate the effect of dispersion and nonlinearity in long ~ 40 km fibers on the transmission of information by chaotic carrier waveforms (fiber optics, chaotic communications).
10) Richard Lepkowicz: involved in full vacuum cavity studies of a visible chemical laser system

(spring and summer quarters) (optical and vacuum techniques, lasers, chemical physics).
11) Christopher Meacham: interfaced a phase modulated Schmitt trigger to a PC for data acquisition as a way of understanding forms of stochastic resonance (applied physics, mastery of useful software packages including LabView, mathematica, Igor Pro, etc.).
12) Devang Naik: involved primarily in the study of kinetically controlled lithation for the formation of new alloys for battery applications. Also involved in the study of porous silicon photovoltaics (vacuum technology, high temp. synthesis, laser induced fluorescence and material science).
13) Candace Osborne: studied optical lattice traps for cavity QED (high power lasers, ultrahigh vacuum, rf electronics, optics).
14) V. Reid Smith: studied the theory of quasi-1d and quasi-2d superconductors at high metallic fields attempting to understand a possible phase transition between singlet and triplet superconducting states (quantum mechanics and numerical techniques).
15) Glen Stark: developed a comprehensive numerical code for solving the Boltzmann kinetic equations by simulating the classical trajectories for colliding atoms inside a magnetic trap (quantum mechanics, numerical analysis).

Publications Involving Undergraduates (underlined)

A number of research publications have resulted from our summer research program and we anticipate that additional papers, which involve more complex-longer ??? will be published. In addition, several of the students have presented their results at regional physics meetings and to their home institutions.

John F. Lindner, Brian K. Meadows, Tracey L. Marsh, William L. Ditto, and Adi R. Bulsara, "Can Neurons Distinguish Chaos from Noise?", International Journal of Bifurcations and Chaos, in press.

P. N. First, J. A. Bonetti, D. K. Guthrie, L. E. Harrell, and S. S. P. Parkin, "Ballistic Electron Emission Spectroscopy of Magnetic Multilayers", (abstract) J. Appl. Phys. 81, 5533 (1997).

G. N. Henderson, P. N. First, T. K. Gaylord, E. N. Glytsis, B. J. Rice, P. L. Dantzscher, D. K. Guthrie, L. E. Harrell, and J. S. Cave, "A. Low-Temprature Scanning Tunneling Microscope for Ballistic Electron Emission Microscopy and Spectroscopy", Rev. Sci. Instrum. 66, 91 (1995).

S. Zhu, K. S. Thornburg, G. D. Van Wiggeren, D. DeShazer, R. Roy, and P. Ashwin, "Synchronization of Chaos in a Linear Three Laser Array", in preparation for submission to Physical Review E.

J. Hales, R. Roy, and M. Dykman, "Optimal Paths and the Prehistory Problem for Semiconductor Laser Power Dropout", in preparation for submission to Physical Review Letters.

J. M. Stephens, John Stout, Joseph Abraham, and Martin Neumann, "Measurement of Low-Level Gain in a Visible Chemical Laser Amplifier", Applied Optics, to be submitted.

K. K. Shen, X. Qi, and J. V. Pugh, "A Chemiluminescent and Laser Induced Fluorescent Probe of the Low-Lying $B^2\Pi$ State of the Alkali Oxides LiO and NaO: Evidence for Alkali Atom (M^2S, M^2P) and Alkali Dimer Chemiluminescent Reactive Encounters", in preparation.

J. L. Gole, P. Lillihei, L. Seals, and J. A. DeVincentis, "Correlation of Porous Silicon Pore Structure with Photovoltaic Response and Photoluminescence - A Connection Between Bulk and Surface Properties", Applied Physics Letters, submitted.

J. L. Gole, L. Seals, P. Lillihei, J. A. DeVincentis, and L. A. Bottomley, "Chloride Salt Stabilization of Porous Silicon Surface", in preparation.

J. L. Gole, L. Seals, J. A. DeVincentis, and L. A. Bottomley, "Optical Pumping of Dye Complexed Porous Silicon to Increase Photoluminescence Emission Rates", in preparation.

D. Howell, T. Heath, W. Huang, M. McKenna, and M. Schatz, "Damping of Surface Waves in a Circular Container", in preparation.

It will be noted that the number of publications during this grant period appears to be down from the previous grant period. In large part this is the result of undergraduate student participation in longer term projects and, in some respects, results from the Olympic year arrangement for the program. Those publications which will result from the third year of the program are not yet completely documented and we anticipate additional publications from second year participation.

Shared Experiences

At frequent intervals during the summer, especially the Wednesday afternoon seminars where the students met as a group with faculty participants to hear from experts on a variety of research topics and also present their own short seminars, discuss research projects, academic plans, and the general research experience. These sessions provided one of the summer's most useful learning experiences. Students realized through their pooled experiences that their successes and frustrations with individual projects were shared by other participants. Of particular interest was the evolution of students' attitudes toward their work: initially intimidation, later a growing enthusiasm, and finally accomplishment, confidence, and triumph. Thus each participant developed a realistic view of physics research. Further, several students mentioned toward the end of their stay that the program had imparted to them a real sense of teamwork and synergy in research. In some cases the students were allowed to participate individually or in groups in one course covering topics which were not available to them at their home institution. Off-campus structured programs included a "traditional July 4th dinner and fireworks, run by the PI, a tour of the Lockheed Aircraft Company Assembly and Construction line, and arranged tours of select groups in the Georgia Tech Experiment Station. In the summer of 1997, we were fortunate to receive a special seminar from the chief engineer for NASA's Pathfinder mission. In addition students remarked that they experienced a growing comaraderie through extracurricular activities. Without being oppressively structured, we encourage the students to form groups of mutual interest. For example, the symphony group formed in the initial REU meetings, facilitates students (1) purchasing group discount tickets to the summer program and (2) arranging for group travel to weekend concerts at the parks around Atlanta. Extracurricular activities also have included camping and sports, however these are left completely to the students discretion. We allow the students to be the primary determinant of the many activities in and around Atlanta in which they can participate.

Discussions with Graduate Students

Most of the REU students had not had previous opportunities to interact with graduate students. They cited these contacts as valuable for learning research techniques and, perhaps more importantly, for assessing the challenges of graduate school.

Almost all of the REU participants in this program are now in graduate school, will be entering in the fall, or have confirmed the intent to pursue graduate study immediately. The few exceptions will attend medical school or must fill service obligations before going on to graduate study. All now have strong feelings about their relative aptitudes for experimental vs. theoretical research, and all feel better able to make an informed choice about fields of research, "big" vs. "little" physics, large vs. small department, etc.

Recruitment of Participants

Recruitment material (attached - Appendix A) was sent to department heads and individuals at 450 physics departments, 130 around the southeast and the remainder throughout the United States. Material was also sent to several additional students, through the U. S. who inquired about the program. Material was sent to highly qualified Georgia Tech Students in January following an initial October-November mailing.

APPENDIX A

November 4, 1997

Dear Colleague:

The Chemical, Condensed Matter, Nonlinear and Optical Physics groups in the School of Physics at Georgia Tech will be offering an NSF-funded Research Experience for Undergraduates program for the summer of '98, in a format similar to our highly successful REU programs of the last nine years. We would like to solicit your assistance in bringing the program to the attention of qualified applicants.

We will employ approximately fourteen students from institutions around the country. In choosing participants, we will be aiming for a group well-balanced in race and gender. A strong academic record, indicating a student's potential for graduate study, will be required. We have enclosed information about the program and about our groups. You must not have graduated from his/her undergraduate institution at the time of participation in the program.

Sincerely,

James L. Gole
ph294jg@prism.gatech.edu

Michael Chapman	Mei-Yin Chou	Edward Conrad
William Ditto	Phillip First	Brian Kennedy
Kevin O'Donnell	Donald O'Shea	Rajarshi Roy
Carlos Sa de Melo	Michael Schatz	Li You
Andrew Zangwill		

Research Experience for Undergraduates

Chemical, Condensed Matter, Nonlinear, and Optical Physics
School of Physics, Georgia Institute of Technology

The School of Physics at Georgia Tech solicits applications for the Research Experience for Undergraduates Program (supported by the National Science Foundation) for the summer of 1998. This program provides research opportunities for undergraduates in chemical, condensed matter, nonlinear, and optical physics. It is part of a continuing effort on the part of Georgia Tech's School of Physics to provide educational opportunities for students at all levels. The extensive experience of the Georgia Tech chemical, condensed matter, nonlinear, and optical physics groups in undergraduate research makes this an ideal environment for summer research.

What previous REU Fellows have said about our program:

- "There is NO better way to evaluate whether you want to go to grad school."
- "I really enjoyed the program because it gave me the opportunity to work in a larger lab than I was used to."
- "There was an air of mutual respect, which not only improved the quality of my work, but made it a pleasure to come in every day."
- "I have seen first-hand what graduate student study and life are like and have also learned more physics in the process."
- "I feel that the REU Program would be a tremendous help to anyone who is seriously considering a career in a field of science- it certainly was to me."
- "Probably more important than what details I might have learned or what things I might have made are the valuable insights I gained into experimental research, graduate school, and my own abilities and inabilities."
- " I learned a lot of very good information from grad students."
- "The whole time I was here I felt as if I was part of the effort rather than just a summer employee."
- "I now have a detailed understanding of what is involved in the design, construction, operation and maintenance of laboratory apparatus."
- "There were no solution guides… I learned to trust my instincts."
- "I now realize that there is a lot I don't know, but there's nothing I can't learn."
- "I know the pride of having a piece of apparatus you designed sitting in front of you, complete."

Stipends will be $2850 for the ten-week program. A travel allowance will be available for transportation to and from Atlanta. Support is also available for student travel to present results at regional science conferences.

Selection of REU participants:

Potential REU participants are encouraged to submit the following application materials:
- A complete application (form attached).
- Two letters of reference from faculty members familiar with the student's abilities and performance (form attached).
- A current transcript.

Applications received by March 1, 1998 will be assured of full consideration. A strong academic record is required. Preference will be given to rising seniors, but exceptional students at earlier stages of undergraduate studies will also be considered. Minority and female candidates are strongly encouraged to apply. Participants must be U.S. citizens or permanent residents.

Georgia Institute of Technology
School of Physics
Research Experience for Undergraduate Program
Letter of Recommendation

Name of Applicant: ______________________________

College or University ______________________________

Name of Faculty respondent: ______________________________

Under the provisions of the Family Educational Rights and Privacy Act of 1974, I hereby waive my right to inspect the recommendation given below with the understanding that it will be used only for purposes of consideration for an undergraduate summer research award.

______________________________ ____________
Signature Date

____
Social Security Number

Note to respondent:

We appreciate your opinion of the applicant named above. We are interested in how long and how well you have known the applicant, in your impression of the applicant's initiative, intellectual power, perseverance, resourcefulness, experimental skill, ability to organize, and the applicant's potential for graduate study.

______________________________ ______________________________
Signature of respondent Position of respondent

____
Telephone number of respondent

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Georgia Institute of Technology
School of Physics
Research Experience for Undergraduates Program
Letter of Recommendation

Application form: Research Experience for Undergraduates
Georgia Institute of Technology, School of Physics

Name: ______________________ Permanent Address: ______________________

Address: ______________________

Phone: ______________________

E-mail: ______________________

Social Security Number: ______________________

Academic experience (names of colleges attended, major field of study, anticipated date of graduation, GPA):

Honors, awards, recognitions:

Work experience (employer, type of work, dates of employment):

Academic and career objectives:

Practical experience in research laboratories, academic instructional labs, electronics, computer interfacing, automotive repair, construction, design, etc.:

Experience in computer programming, fluency in computer languages:

Specific area of interest for REU program (experiment vs. theory, or a particular group or project), if strong preference exists: ______________________

Dates available for REU program during Summer 1998: ______________________

Send application materials to:

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Research activities of REU participants are described below. Many common elements link the research areas of our groups: laser techniques, laser development, molecular and chemical physics, reaction dynamics, and assorted surface diagnostics. The highly unified yet diverse program will offer each student an overview of current research in chemical, condensed matter, nonlinear, and optical physics as well as in-depth knowledge of a particular research area. REU students will also participate in undergraduate student seminars with informal presentation of research projects and open discussion. This forum guarantees contact with ongoing undergraduate and graduate research and promotes the exchange of ideas, designs, and laboratory techniques.

Michael Chapman's laboratory investigates fundamental topics in contemporary quantum mechanics by manipulating the quantum behavior of single atoms and photons. This research employs lasers to confine and cool small samples of atomic vapor to micro-Kelvin temperatures inside a vacuum chamber. These samples then provide a starting point for quantum studies including fundamental atom-photon interactions and atom optics and interferometry involving the manipulation of the atomic de Broglie wave. REU students will gain experience in state-of-the-art laser and optical technologies, as well as high-speed electronics and vacuum technology.

Mei-Yin Chou studies the electronic and structural properties of solids, surfaces and clusters by first-principles quantum mechanical calculations. These studies examine defects and impurities in semiconductors and metals, the dynamical properties of crystals, chemisorption problems on surfaces, and the thermodynamic properties of a lattice gas. Most calculations will be done on high-performance workstations and supercomputers. Students will gain experience in working with vector and parallel computers to solve problems by numerical methods, as well as in computer graphics.

Edward H. Conrad is now testing a new Magneto-Optical Kerr system being built at Georgia Tech. This equipment will be used to study the influence of atomic steps on the magnetic properties of thin films. This work is part of a broader program to understand magnetic interactions on length scales equivalent to next generation magnetic storage devices.

William Ditto and the Applied Chaos Lab researches basic and applied chaotic phenomena through a series of computer simulations and physical/biological experiments involving magnetoelastic ribbons, coupled circuits and heart/brain tissue. Ongoing projects include (1) the formation and control of chaos in heart and brain tissue, (2) spatiotemporal chaotic behavior of coupled oscillators (3) stochastic resonance in coupled systems, (4) strange nonchaotic behavior of quasiperiodicallay driven systems, and (5) chaos based computing.

Phillip First conducts experimental studies of the surface properties of materials at the atomic scale. This research utilizes the scanning tunneling microscope (STM) to attain atom-by-atom resolution of surface ordering and thin film growth processes. A related field of research employs the STM as an injector of electrons for the study of ballistic electron transport in thin films and semiconductor multilayer structures. Students will learn fundamentals of surface physics, ultrahigh vacuum techniques, surface analysis, low temperature techniques, electronics and computer interfacing.

James Gole's research investigates the formation of small metal clusters and the dynamics of oxidation reactions involving these clusters, ultrafast energy transfer among the excited states of high temperature molecules, visible chemical laser development, kinetically controlled lithiation for alloy and battery fabrication and laser induced photoluminescence from silicon based cluster oxides and porous silicon surfaces. A combination of chemiluminescent, laser fluorescent, mass spectrometric, and electron optics techniques is applied. Students will gain experience in high vacuum techniques, the application of material science methods to the development of useful high-temperature systems, the application of plasma sources, optical techniques, and the development of laser technology.

Brian Kennedy conducts theoretical research in quantum optics. General areas of interest include novel atom-photon interactions, cavity quantum electrodynamics, quantum noise and statistical properties of the electromagnetic field, and Bose-Einstein condensation in atom gases. Other research involves light propagation in nonlinear optical fibers and the nonlinear dynamics of coupled lasers. A wide range of analytical and numerical methods are employed in the research.

Kevin O'Donnell's laboratory studies the optical scattering properties of surfaces that may be either periodic or randomly rough. Particular recent interest has been in the excitation of surface plasmon polaritons; effects such as anomalous absorption, diffuse light bands and backscattering enhancement may be observed. Undergraduate research projects involve the fabrication of nanometer-scale surface structures using optical techniques, optical system development from infrared to ultraviolet wavelengths, holographic grating fabrication and the polarimetry of light.

Donald O'Shea is applying microcomputers and desktop publishing to the design, fabrication and testing of diffractive optical elements (DOEs). These elements, which include lenses, gratings, and wavefront generators, are made using integrated circuit fabrication techniques. An REU student will investigate new DOE designs.

Rajarshi Roy's laboratory investigates practical optical devices and systems such as semiconductor lasers, solid state lasers and optical fibers; these serve as test beds for fundamental new concepts in nonlinear and statistical physics. A goal is to bridge the gap between nonlinear dynamics and quantum physics and to explore microscopic and macroscopic optical phenomena with the latest measurement and analytic tools. How do quantum fluctuations at the microscopic level reveal themselves in the nonlinear dynamics of macroscopic systems? Such basic questions are directly related to practical goals such as the development of techniques to control single chaotic lasers and two dimensional laser arrays.

Carlos A. R. Sa de Melo conducts research in theoretical condensed matter physics. Special attention is given to superconductivity in high magnetic fields. This program involves strong connections with experimental work being performed at the National High Magnetic Field Laboratory, at Princeton University, at the University of California at Los Angeles, and at the State University of New York at Buffalo. Other research involves the study of mesoscopic quantum phenomena and the possibility of quantum computing using magnetic, ferroelectric, and superconducting systems. A program on classical and quantum biophysical phenomena in DNA molecules is also being developed.

Michael Schatz studies pattern formation in systems in nature. A goal is to understand the fundamental mechanisms of pattern formation by studying experiments in fluid flows. Currently, experiments on surface-tension-driven flows and flows driven by time-dependant acceleration are being sponsored by NASA because they address questions about how fluids behave in the "microgravity" environment of space.

Li You conducts theoretical research in a wide area of light/matter interaction. Current investigations center around topics of interest to experimental groups in atomic, molecular, and optical physics. The REU students will work with graduate students on selected topics in atom optics, laser cooling and trapping of atoms, Bose-Einstein condensation, and quantum optics. It is expected that valuable experience will be gained in both numerical computation and analytic skills.

Andrew Zangwill conducts theoretical studies of epitaxial phenomena. That is, the physics associated with the growth and properties of "designer" solids that are fabricated one atom at a time. Currently, interest focuses on the morphological and magnetic behavior of such systems. The methods of analysis range from the construction of stochastic partial differential equations to Monte Carlo computer simulations.

Housing

Dormitory facilities are available over the summer months at Georgia Tech. Dormitories are conveniently located on campus. Fees for summer 1998 are expected to be $850 for the eleven-week summer quarter ($775 for 10 weeks). Most dormitories have kitchen facilities. A cafeteria is located nearby in the Student Center. Participants will have full access to campus facilities, including the library and the Student Athletic Complex.

Questions and applications should be addressed to:

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